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(54) **Mercury-free metal halide lamp, its contents and electric power control depending on resistance property**

(57) A metal halide discharge lamp (10) comprising a light emitting tube (1), the light emitting tube (1) comprising a discharge chamber (2) formed in the light emitting tube and containing no mercury, a pair of electrodes (3) each having a portion which projects into the discharge chamber (2), wherein the discharge chamber (2) comprises a buffer gas of xenon (Xe) in an amount of 7-20 atmospheres at room temperature which also acts as a starter gas and at least one kind of a metal halide. The light emitting tube (1) has a range of positive resistance property in current-voltage characteristics relative to a varying input electric power, and in the range of positive resistance property, the light emitting tube (1) is driven by an electric power which is equal to or smaller than a rated power supplied during steady lighting. In the metal halide lamp (10) of the present invention, even if the input electric power of the light emitting tube (1) is varied, sudden unintentional extinguishing does not occur, and a range of light color variation is narrowed.

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a high-intensity discharge lamp, which can be called a metal halide lamp, for use in a vehicle headlamp, fog lamp etc. and other illumination devices, and more particularly it relates to a mercury-free high intensity discharge lamp with high lumen output efficiency in the wavelength range of visible light, with appropriate color rendering property and with excellent discharge stability, enabling practical dimming of a headlight incorporating the mercury-free high intensity discharge lamp.

Deseription of the Related Art

[0002] In a conventional high-intensity discharge lamp such as a metal halide lamp, mercury has been used not only as a light emitting material, but also as a buffer gas in order to promote the vaporization of other light emitting materials by increasing the temperature of a light emitting tube and to adjust a lamp voltage of the light emitting tube. The lamp voltage can be understood as a voltage of the light emitting tube during steady lighting of the high intensity discharge lamp comprising the light emitting tube. Here, steady lighting means a state of lighting after a start-up or initial lighting period has finished. However, mercury is a toxic substance which causes damage to the environment. Therefore, it has been a long-felt need for manufacturers of high-intensity discharge lamps to develop a light emitting tube which does not contain mercury.

[0003] In one conventional metal halide lamp, a light emitting tube which comprises no mercury (referred hereinafter as "a mercury-free light emitting tube") can be made by sealing a starter gas such as xenon (Xe) gas into the light emitting tube. The amount of sealed Xe gas corresponds to a few atmospheres or more at room temperature. Room temperature means substantially a normal temperature. Metal halides on a wall of a discharge chamber of the light emitting tube are vaporized by heat transferred from the xenon arc having high temperature to the wall of the chamber.

[0004] In the conventional mercury-free light emitting tube, major light emitting materials are metal halides which have similar thermodynamic properties to mercury. However, the conventional mercury-free metal halide lamp has different light emitting characteristics from the conventional mercury-containing metal halide lamp. For example, in the conventional mercury-containing metal halide lamp, if a dimming function is operated by decreasing input electric power of the metal halide lamp, the color of light emitted from the light emitting tube greatly changes, because the intensity of light emitted from mercury having relatively high vapor pressure is maintained while the emission of light from metals which are sealed or contained in the light emitting tube in the form of metal halides greatly decreases. On the other hand, in the conventional mercury-free metal halide lamp, if the input electric power of the metal halide lamp is decreased, the color of light emitted from the light emitting tube changes in a smaller range, because light emission from each metal decreases while keeping in the discharge chamber substantially the same ratio of all the metals to each other, and light emitted from each of the metals collectively constitute light from the light emitting tube. However, the conventional mercury-free metal halide lamps have problems which are described later in detail with reference to Japanese Patent Publications.

[0005] In another conventional light emitting tube capable of instant lighting-up, a starter gas comprising Xe gas is sealed in the discharge chamber in an amount of more than a few atmospheres at room temperature, and a multiple of a rated current is supplied in an initial lighting period just after start-up of the light emitting tube. When the light emitting tube is started up from room temperature (referred hereinafter as "cold start"), electrodes disposed in the light emitting tube are heated to temporarily reach a high temperature, which expedites deterioration of the electrodes. Further, in a light emitting tube made of silica glass, electrodes which are made of tungsten are embedded in sealed portions of the light emitting tube located adjacent the discharge chamber. In this structure, mercury and metal halides creep and stay in a gap between the electrodes and the sealed portions when the light emitting tube has cooled after turn-off of the light emitting tube. Such mercury and metal halides located in the gap are instantly vaporized by the steep temperature rise on cold start of the light emitting tube, which may destroy the sealed portions of the light emitting tube at locations where the electrodes are embedded. The lifetime of this kind of light emitting tube is substantially determined by the number of times of cold starts rather than by the lighting hours. In case the metal halide lamps are used in devices which are frequently and repeatedly turned on and off, lifetime of the light emitting tube can be greatly improved if the turn-off is substituted by dimming.

[0006] Japanese Patent Publication No. 6-84496 discloses a mercury-free high pressure metal halide discharge lamp capable of dimming. According to an embodiment of the patent publication, the high pressure metal halide discharge lamp comprises 20mg NaI, 4mg ScI_3, and Xe gas which is sealed into a discharge chamber in an amount of approximately 8 atmospheres at room temperature. Rated electric power of the high pressure metal halide discharge lamp is 150 W. If the rated electric power is decreased to 75 W, the light color of the lamp is maintained, and a certain level of dimming without accompanying strangeness to a viewers eye is achieved. Further, the lamp voltage of approximately 90V is achieved by setting the multiplication product of

Xe gas pressure (atm.) and a distance between the electrodes (mm) to be equal to or larger than 40.

[0007] According to results of trials and experiments conducted by the inventor, a combination of NaI and ScI_3 is able to provide a relatively good color rendering property and color reproducibility, i.e., color maintenance property between before and after dimming, and a high lumen output efficiency. However, the color of the light obtained by the combination is rather greenish, and not pure white. According to our testing and experiments, in a chromaticity diagram, the obtained light did not fall within the scope of tolerance area of white light for use as an automobile light. Accordingly, usage of the high pressure metal halide lamp as a light source of illumination devices is limited depending on the required color rendering property of the illumination devices.

[0008] A lamp voltage is determined by the sum of a voltage drop caused by electrodes and an impedance produced by, for example, an electron scattering effect at metal atoms and also produced by attachment of electrons to free halogens. Mercury greatly causes the occurrence of voltage, because it has an especially large collision cross section for an electron. According to the embodiment of the patent publication, no mercury is contained in the chamber of the light emitting tube. However, for the light emitting tube the same voltage was achieved as for the mercury-containing light emitting tube. It is understood that the vapor pressure of the metal halides was increased by operating the light emitting tube at a very high temperature. Since the vapor pressure of the metal halides is very high, it causes devitrification of the wall of the chamber and deterioration of the electrodes, because a reaction of silica glass constituting the light emitting tube and metal halides is promoted.

[0009] Japanese Patent Publication No. 11-238488 discloses a substantially mercury-free metal halide discharge lamp comprising a first halide being a halide of at least one metal selected from the group consisting of sodium, scandium, and a rare earth metal, capable of a predetermined light emission, a second halide having a relatively high vapor pressure and a tendency of not emitting visible light, said second halide being a halide of at least one metal selected from the group consisting of aluminum (Al), iron (Fe), cadmium(Cd), zinc (Zn), tin (Sn), manganese (Mn), chromium (Cr), gallium (Ga), rhenium (Re), magnesium (Mg), cobalt (Co), nickel (Ni), beryllium (Be), titanium (Ti), zirconium (Zr), hafnium (Hf), and antimony (Sb), and rare gas sealed in a discharge chamber of the discharge lamp. The metal halide discharge lamp contains substantially no mercury.

[0010] The second halide acts as a buffer gas, and produces the same lamp voltage as mercury. Efficiency of the lamp of this patent publication is improved by: 1) providing sufficiently high lamp voltage which makes the lamp current small, thereby preventing an increase of current capacity of the illumination devices incorporating the metal halide discharge lamp or of a circuit connected to the metal halide discharge lamp; and 2) reducing the energy loss caused by electrodes. Further, it is also disclosed that a range of light color change on dimming of the metal halide discharge lamp is narrowed.

[0011] However, according to results of tests and experiments made by the inventor, the second halide emits light in an ultraviolet wavelength range, which does not contribute to lumen output in the wavelength range of visible light. In the metal halide discharge lamp according to this patent publication, although the lamp voltage takes an approximate value similar to that of the metal halide discharge lamp comprising mercury, lumen output efficiency in the wavelength range of visible light of the conventional metal halide lamp free of mercury is smaller than the one of the conventional metal halide lamp comprising mercury.

[0012] Further, depending on additive amount of the second halide, the halogen density during lighting is excessively increased, which tends to cause an unstable discharge. In a state of unstable discharge, if current and electric power are controlled to dim the light device incorporating the metal halide discharge lamp, often unintentional extinguishing of the lamp may happen caused by discharge stop which may occur relatively soon after start of an unstable discharge. Further, shading of the ultraviolet light rays caused by addition of the second halide is required depending on its wavelength and intensity.

[0013] Regarding the usage of the metal halide lamp as a light source of an automobile headlight, a day-time running lamp (referred hereinafter as "DRL") is required by regulations in some countries. The DRL provides light distribution in high-beam mode for illuminating a distant front area with smaller intensity than the one of a high-beam, while maintaining a color rendering property of the light. However, for DRL there has not yet been used any conventional metal halide lamp. The conventional metal halide lamp containing mercury is not able to be operated for dimming because of the light color change described above. The conventional mercury-free type metal halide lamp has problems described above when dimming is operated.

[0014] Of course, not only being used as a light source of an automobile headlight, but also being used in various applications requiring to emit white light, it is preferable that the metal halide lamp is capable of performing a reliable dimming function, i.e. adjusting the light amount as required while maintaining a color rendering property of the light, for efficient white light emission.

[0015] Therefore, the present invention is intended to provide a high intensity discharge lamp which is completely free from mercury and capable of providing high lumen output efficiency in the visible light wavelength range and appropriate color rendering property with a superior discharge stability enabling the practical use of the high intensity discharge lamp with dimming function.

SUMMARY OF THE INVENTION

[0016] In order to resolve the aforementioned problems in the related art, the present invention provides a metal halide discharge lamp having following characteristics. In a first aspect of the present invention, a metal halide discharge lamp comprises a light emitting tube, the light emitting tube comprising a discharge chamber formed in the light emitting tube and containing no mercury, a pair of electrodes each having a portion of which projects into the discharge chamber, wherein the discharge chamber comprises a buffer gas of xenon (Xe) in an amount of 7-20 atmospheres at room temperature which also acts as a starter gas, and at least one kind of a metal halide. The lamp has a range of positive resistance property in current-voltage characteristics relative to a varying input electric power, and in the range of positive resistance property, the light emitting tube is driven by an electric power which is equal to or smaller than a rated power supplied during steady state of lighting. The steady state of lighting means a state of lighting after a start-up lighting period has finished. In the steady state of lighting, the state of discharge is stable and an amount of luminous flux of the discharge lamp is stable as long as dimming operations are not performed. It is usual that a rated electric power is supplied to the discharge lamp during the steady lighting period. In the metal halide lamp of the present invention, even if the input electric power of the light emitting tube is varied, flickering or sudden unintentional extinguishing does not occur, and a range of light color variation is narrowed.

[0017] In a second aspect of the present invention, in the range of positive resistance property in current-voltage characteristics relative to a varying input electric power, electric power supplied to the light emitting tube is equal to or larger than 57 % of the rated electric power supplied in the steady lighting period. By setting the electric power to be in the above-described range, superior discharge stability which is appropriate for dimming light intensity of the headlight is provided.

[0018] In a third aspect of the present invention, in the range of positive resistance property in current-voltage characteristics relative to a varying input electric power, a total luminous flux varies in a range of 19-100 % relative to a luminous flux of the metal halide lamp during steady lighting. The range of the total luminous flux provides a range of varying amount of light from the light emitting tube for use in the automobile headlight capable of dimming light intensity with stable discharge.

[0019] In a forth aspect of the present invention, in the range of positive resistance property in current-voltage characteristics relative to a varying input electric power, the input electric power varies in a range such that a color of light emitted from the light emitting tube stays in a range of substantial white, enabling smooth dimming without accompanying great change of a color rendering property which can be perceived by human eyes with strangeness. The substantial white means the following range in CIE 1931 xy chromaticity diagram.

$$x \geq 0.345 \; y \leq 0.150 + 0.640x$$

$$x \geq 0.405 \; y \leq 0.050 + 0.750x$$

[0020] The above range of chromaticity is consistent with a chromaticity range as specified in JEL 215 published by Nihon Denkyu Kogyo-kai for high intensity discharge lamps such as metal halide lamp of D2R type and D2S type used as a light source of an automobile headlight.

[0021] In a fifth aspect of the present invention, the metal halides comprise at least sodium iodide (NaI) and scandium iodide (ScI_3), thereby high lumen output efficiency in the visible light wavelength range is achieved.

[0022] In a sixth aspect of the present invention, a mol fraction of ScI_3 relative to NaI is in a range of 0.10-0.43, thereby a superior visible lumen output efficiency is achieved.

[0023] In a seventh aspect of the present invention, the metal halides further comprise indium iodide (InI) in addition to NaI and ScI_3. A mol percent of InI relative to all metal halides is in a range of 3-12 mol %, thereby white light emission is achieved while limiting a decrease of visible lumen output efficiency to an acceptable level for the use as automobile light.

[0024] In a eighth aspect of the present invention, a sum of molarities of all metal halides relative to an inner volume per unit of the light emitting tube is in a range of 30-100 μmol/cm^3, thereby minimizing a decrease of lumen output efficiency and a change of chromaticity even after many lighting hours, and also suppressing shading of light and unfavorable coloring to a predetermined color of emitted light by not vaporized metal halides.

[0025] In a ninth aspect of the present invention, in a period from start-up of the light emitting tube until it reaches steady lighting, an electric power equal to or smaller than 300 % of rated power is supplied to the light emitting tube, thereby instant lighting-up of the light emitting tube is possible.

[0026] In a tenth aspect of the present invention, a rated electric power of the light emitting tube is 35W, and a lamp voltage of light emitting tube just after start-up is in a range of 15-25V. Further, a lamp voltage of light emitting tube in steady lighting is in a range of 30-50V. In the above-determined range of electric power, the metal halide discharge lamp provides an optimized electric property for use in an automobile headlight.

[0027] In an eleventh aspect of the present invention, the metal halide discharge lamp can be driven by direct current.

[0028] In a twelfth aspect of the present invention, the light emitting tube has a range where an impedance of the light emitting tube is equal to or smaller than 75Ω in

current-voltage characteristics relative to a varying input electric power, and the light emitting tube is driven during steady lighting by an electric power which is equal to or smaller than a rated power. A mol fraction of ScI_3 relative to NaI is in a range of 0.05-0.43, thereby superior lumen output efficiency in a wavelength range of visible light is achieved

[0029] In a thirteenth aspect of the present invention, the rated electric power of the light emitting tube is in a range of 10-50W, thereby a size of the light emitting tube, which is appropriate for both instant lighting-up and dimming operation, is determined.

[0030] In a fourteenth aspect of the present invention, a lamp voltage of the light emitting tube with a rated electric power in the range of 10-50W is in a range of 20-65V in steady lighting, thereby appropriate voltage and current for dimming operation of the light emitting tube are obtained. The electric power supplied to the light emitting tube during steady lighting varies in a range of approximately 40-100 % of the rated electric power during steady lighting, thereby a discharge without unintentional extinguishing during a dimming operation can be achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

FIG. 1 is a schematic view of a metal halide lamp according to any of the preferred embodiments of the present invention;

FIG. 2 is a graph showing lumen output efficiency in the visible light wavelength range of a light emitting tube with rated electric power of 35W into which NaI and ScI_3 totaling 0.4mg are sealed, as a function of mol percent of ScI_3 relative to all metal halides in the light emitting tube;

FIG. 3 is a graph showing chromaticity change of a light emitting tube with rated electric power of 35W comprising InI in addition to NaI and ScI_3 depending on additive amount of InI;

FIG. 4 shows a spectrum distribution of a light emitting tube according to a second preferred embodiment of the present invention said light emitting tube which has InI added at a ratio of 10.3 mol % relative to all metal halides in the light emitting tube;

FIG. 5 is a graph showing lumen output efficiency in visible light wavelength as a function of additive amount of InI in the metal halide discharge lamp according to the preferred embodiment of Fig. 3;

FIG. 6 is a graph showing current-voltage properties of the metal halide discharge lamp according to the preferred embodiment of Fig. 4;

FIG. 7 is a graph showing the relationship of total lumen output of the light emitting tube and input electric power supplied to the light emitting tube according to the preferred embodiment of Fig. 4;

FIG. 8 is a diagram showing the chromaticity change of light emitted from the light emitting tube when the input electric power supplied to the light emitting tube according to the second preferred embodiment of the present invention is decreased from the rated electric power of 35W;

FIG. 9 is a graph showing lumen maintenance property of the light emitting tube according to the second preferred embodiment of the present invention with rated electric power of 35W;

FIG. 10 is a diagram showing the chromaticity change of light emitted from the 35W light emitting tube according to the second preferred embodiment of the present invention in comparison with the chromaticity change of light emitted from the conventional mercury-containing 35W light emitting tube for use in automobile headlight.

Fig. 11 shows lumen start-up properties of the light emitting tube of the second preferred embodiment depending on varying initial input electric power.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] A detailed description of the present invention will now be given based on embodiments shown in the drawings. Whenever possible, the same reference numbers are used throughout the drawings to refer to the same or like parts.

[0033] Fig. 1 shows a metal halide discharge lamp 10 comprising a light emitting tube 1 according to a preferred embodiment of the present invention. In the present invention, light emitting tubes having the same structure as in Fig. 1 are used throughout any of the tests and experiments made by the inventor, as long as not being specified. A light emitting tube 1 made of silica glass comprises an inside formed discharge chamber 2. An inner volume of the discharge chamber is approximately $28.0\times10^{-3}cm^3$. A pair of electrodes 3 made of a high melting point material such as tungsten is embedded in the light emitting tube 1 such that one end of each electrode projects into the discharge chamber 2. A metal foil 4 and a lead wire 5 are arranged respectively to correspond to each electrode 3. The metal foils 4 made of molybdenum, etc. are respectively connected by welding, etc to the corresponding electrodes 3 on the side of the discharge chamber 2 and they are also connected to the corresponding lead wires 5 on the side opposite to the discharge chamber 2. The electrodes 3 except the portions projecting into the discharge chamber 2, the metal foils 4, and the lead wires 5 are air-tightly embedded by pinch-sealing, etc into silica glass constituting the light emitting tube 1, to thereby provide an electric connection to the electrodes 3. The lead wires 5 are connected to a metallic end of the lamp 10 disposed in a socket and an electric power supply circuit (not shown), and provide electric power to the metal foils 4 and electrodes 3. Each of the pair of electrodes 3 can be made of the same material with the same dimensions. The

electric power supply provides alternating current to the light emitting tube 1.

[0034] The discharge chamber 2 comprises at least one metal halide and a buffer gas of xenon (Xe) in an amount of 7-20 atm. at room temperature which also acts as a starter gas. With start of discharge, an arc having a high temperature is formed by the Xe gas. A luminous flux emitted by the Xe amounts to more than 25 % of a rated luminous flux.

[0035] In the metal halide lamp 10 with rated electric power of 35W for use in automobiles, the rated luminous flux required by regulations in Europe and Japan is 3200 lm with a tolerance of plus minus 450lm. 25% of the rated luminous flux is a required amount by regulations as luminous flux within 1 second from start-up of the light emitting tube 1 used as an automobile headlight. The luminous flux generated just after start of discharge depends on the sealing pressure of Xe gas. If the sealing pressure of the Xe gas is smaller than 7 atm. at room temperature, it is impossible to reach the 25% of the rated luminous flux. If the sealing pressure of the Xe gas is larger than 20 atm. at room temperature, a pressure within the discharge chamber 2 during lighting is over 120 atm, and it can not keep a sufficient safety factor relative to approximately 240 atm. of an allowable pressure limit for the light emitting tube. In the embodiments of the present invention, the light emitting tube 1 preferably comprises at least sodium iodide (NaI) and scandium iodide (ScI_3).

[0036] Fig. 2 shows lumen output efficiency in the visible light wavelength range of the light emitting tube 1 with rated electric power of 35W comprising NaI and ScI_3 totaling 0.4 mg, as a function of ScI_3 (mol%) relative to all metal halides sealed in the discharge chamber 2. Generally, a lamp having an efficiency of equal to or more than 80 lm/W is called a lamp with high lumen output efficiency. As shown in Fig. 2, the combination of NaI and ScI_3 provides high lumen output efficiency in the visible light wavelength range over a wide range of ScI_3 ratio (mol%) relative to NaI. The visible lumen output efficiency exceeds 80 lm/W when the ScI_3 is more than approximately 5 mol%, with a peak at approximately 30 mol%. It is understood that, in a range of ScI_3 which shows increasing lumen output efficiency in the visible light wavelength range, an amount of formation of a halide compound, sodium scandium iodide ($NaScI_4$), having a high vapor pressure is increased by an increased amount of ScI_3. It is also understood that, in a range of ScI_3 which shows decreasing lumen output efficiency in the visible light wavelength range, increasing the vapor pressure of the metal halides promotes reactions with silica glass constituting the light emitting tube, and increases the pressure of free iodine. Electrons attach to the free iodine, so that a degree of electrolytic dissociation of the arc plasma is decreased such that the light emission declines.

[0037] In a range of Fig. 2 in which the lumen output efficiency in the visible light wavelength range decreases as the ratio of scandium iodine (ScI_3) increases, it is understood that the formation of free iodine is actively performed. This is unfavorable with respect to lifetime of the light emitting tube 1. Accordingly, for the purpose of obtaining a lumen output efficiency of the metal halide lamp 1 equal to or more than 80 lm/W in the visible light wavelength range, a preferable ratio of ScI_3 is in a range of approximately 5-30 mol% relative to all metal halides sealed in the discharge chamber 2 consisting of NaI and ScI_3.. In other words, the mol fraction of ScI_3 relative to NaI is in a range of approximately 0.05-0.43 in case only ScI_3 and NaI are contained in the light emitting tube 1.

[0038] In a specific case where the metal halides sealed in the discharge chamber 2 comprises at least one other material such as indium iodide (InI) for light color compensation in addition to NaI and ScI_3, since InI decreases lumen output efficiency of the metal halide lamp 10, it is preferable to set the ratio of ScI_3 in a range of 10-30 mol% relative to the sum of NaI and ScI_3 sealed in the discharge chamber 2 in order to obtain lumen output efficiency which is equal to or more than 80 lm/W of the metal halide lamp 10 including the at least one other material. In other words, the mol fraction of ScI_3 relative to NaI is in a range of 0.10-0.43 in case ScI_3, NaI and the at least one other material are contained in the light emitting tube 1.

[0039] In a conventional light emitting tube, it is common to set the ratio of ScI_3 to smaller than 10 mol% relative to all metal halides sealed in the discharge chamber 2 comprising NaI and ScI_3. If the ratio of ScI_3 is increased to equal to or more than approximately 10 mol%, the discharge becomes unstable due to the increase of free iodine partial pressure causing an unstable discharge such that flickering or unintentional extinguishing of the discharge is inclined to occur. In the metal halide lamp 10 of the present invention, the impedance of the light emitting tube 1 is controlled to be small, which will be described in detail later. Therefore, a current flowing in the light emitting tube 1 is larger than in the conventional light emitting tube, and the electron density in the light emitting tube 1 is large. Accordingly, although the ratio of ScI_3 relative to all the metal halides is set to be large, the discharge is very stable in the light emitting tube 1. The light emitting tube 1 of the present invention comprises NaI, ScI_3 and, more preferably, also indium iodide (InI),.

[0040] Fig. 3 shows the chromaticity change of light emitted from a light emitting tube 1 with rated electric power of 35W comprising InI in addition to NaI and ScI_3 according to a second preferred embodiment of the present invention. The total amount of all the metal halides sealed in the discharge chamber 2 is 0.4 mg in all samples. The mole fraction of ScI_3 relative to NaI is 0.35. Numbers in the diagram of Fig. 3 show mol percent (mol%) of InI relative to all the metal halides in the discharge chamber 2. An area surrounded by solid lines indicates a tolerance area of white color specified by JEL 215 for a high intensity discharge lamp used as a

light source in an automobile headlight. When the ratio of InI is equal to or larger than approximately 3 mol%, light emitted from the light emitting tube 1 falls within the tolerance of white color. When the ratio of InI is in a range of approximately 0-3%, although light emitted from the light emitting tube 1 is not able to be used as white light of an automobile headlight, the light can be used for other applications such as streetlight, or a light source of a liquid crystal projector device.

[0041] Fig. 4 shows a spectrum distribution of light emitted from the light emitting tube 1 when an additive amount of InI is 10.3 mol%. Indium emits a continuous spectrum with a center wavelength of approximately 451 nm. Therefore, indium compensates light emission in the blue range which tends towards shortage due to lack of mercury such that superior white light emission from the light emission tube 1 is achieved.

[0042] Fig. 5 shows the relationship of lumen output efficiency in the visible light wavelength range and the ratio of indium iodide (InI) which is added to the light emitting tube 1 according to the second preferred embodiment of the present invention. By adding InI to the metal halide sealed in the discharge chamber 2, the lumen output efficiency in the visible light wavelength range is remarkably decreased. In order to achieve a high lumen output efficiency equal to or more than 80 lm/W, the additive amount of InI is limited to equal to or smaller than 12 mol%.

[0043] Accordingly, in order to satisfy both white light emission having the required chromaticity for an automobile headlight and high lumen output efficiency, the additive amount of InI is preferably in a range of approximately 3-12 mol%.

[0044] The total molarity of all metal halides, which is determined by the inner volume per unit in the light emitting tube, is equal to or larger than 30μmol/cm^3, considering loss of metal halides by a chemical reaction etc. during lighting. Further, in order to suppress shading and unfavorable coloring of emitted light by metal halides which are not vaporized and stayed on the wall of the discharge chamber 2, the total molarity of all metal halides in the discharge chamber 2 is preferably equal to or smaller than 100μmol/cm^3.

[0045] The metal halide lamp 10 is connected to and driven by an electric power supply capable of adjusting the output electric power. Fig. 6 shows current-voltage characteristics when the electric power supplied to the light emitting tube 1 is decreased from the rated electric power. The interval among each measured point is approximately 1W. The rated electric power of the light emitting tube 1 is 35W. The light emitting tube 1 comprises NaI, ScI_3 and InI. The mol fraction of ScI_3 relative to NaI is 0.35, and the mol percent of InI relative to all metal halides is 10.3 mol%. The inner volume of the light emitting tube 1 is 28.0×10^{-3}cm^3. The total molarity of all metal halides in the discharge chamber 2 is 2.01 μmol . The molarity of the metal halides in the inner volume per unit is 71.8 μmol/cm^3. The light emitting tube 1 further comprises Xe gas sealed in an amount corresponding to 10 atm. at room temperature.

[0046] The rated electric power 35W supplied to the light emitting tube 1 is constituted by a voltage of 33.5V and a current of 1.05A. From these values, the electric power supplied to the light emitting tube 1 is decreased by controlling the current. Then, down to 17W, a positive resistance property appears, and the lamp voltage of the light emitting tube 1 decreases as the current of the light emitting tube 1 decreases. If the electric power is further decreased from 17W, then a negative resistance property appears, and the lamp voltage of the light emitting tube 1 increases as the current of the light emitting tube 1 decreases. In the negative resistance range of the current-voltage characteristics, unstable discharge such as flickering may start to appear and finally the lamp 1 may be unintentionally extinguished. This tendency is emphasized as input electric power is decreased.

[0047] As a result of various tests and experiments made by the inventor, it was found that, in the range where the positive resistance property appears in the voltage-current characteristics, discharge is sufficiently stable and no problem occurs while decreasing the electric power. However, in the range where the negative resistance property appears in the voltage-current characteristics, the discharge tends to become unstable due to a steep rise of the impedance of the light emitting tube 1. A diverging point between the positive resistance property and the negative resistance property exists at approximately 40-50% of input electric power relative to the rated electric power of the light emitting tube with rated electric power of 10-50W. Further, it is also found that, generally, unintentional extinguishing by a discharge stop is inclined to occur if the impedance of the light emitting tube 1 is larger than 75Ω.

[0048] In the embodiments of the present invention, the impedance of the light emitting tube 1 does not substantially include any reactance. Therefore, the impedance can be understood as pure resistance. In case where metal halides other than NaI and ScI_3 are sealed in the discharge chamber 2, if any material which shows a positive resistance property in a specified range of voltage-current property is selected as one of the metal halides sealed in the discharge chamber 2, such a light emitting tube can perform substantially the same property as the light emitting tube 1 according to the second preferred embodiment of the present invention.

[0049] Fig. 7 illustrates the relationship of the total luminous flux and the input electric power of the light emitting tube 1 according to the second preferred embodiment of the present invention. As the input electric power decreases, the total luminous flux of the light emitting tube 1 decreases substantially linearly. In the range of stable discharge where the positive resistance property is observed, the minimum value of the total luminous flux is approximately 550 lm, which is approximately 19% of the total luminous flux at the rated input electric power. As a result of various tests and experiments

made by the inventor, it was found that, the minimum value of the luminous flux allowed to be decreased while maintaining the discharge without unintentional extinguishingt is approximately 15% of the rated luminous flux. Accordingly, it was confirmed that the light emitting tube 1 has a sufficiently practical dimming ability.

[0050] Fig. 8 illustrates the chromaticity change of the light color emitted from the light emitting tube 1 according to the second preferred embodiment of the present invention when the input electric power of the light emitting tube 1 is decreased from the rated electric power 35W. It does not fall within the tolerance area of white as an automobile headlight on the x-y chromaticity diagram at any part of the range of input electric power showing the positive resistance property in the current-voltage characteristics. However, in the range of input electric power decreasing down to 20W which is approximately 57% of rated electric power, the light emitting tube 1 is able to emit white light in said tolerance area of chromaticity. Accordingly, on dimming of the light, it is possible to maintain the light color to be substantially white by setting the range of the input electric power of the light emitting tube 1 to be equal to or more than 20W.

[0051] The metal halide discharge lamp according to the preferred embodiment of the present invention is applicable for various usage. In a case where the light emitting tube 1 is used as a light source of an automobile headlight, instant lighting up is required ofthe light emitting tube 1. The instant lighting up is achieved by setting the input electric power of the light emitting tube 1 to be larger than the rated electric power during a period from start-up to start of steady lighting.

[0052] Generally, a metal halide discharge lamp for use in automobile headlight is required to have a lumen start-up property of 25% of the rated luminous flux within one second and 80% of the rated luminous flux within four seconds from start-up of the metal halide discharge lamp. In order to achieve the instant lighting-up property, it is usual to supply an initial input electric power during an initial lighting period just after start-up of the metal halide discharge lamp to the metal halide discharge lamp, which is larger than the rated electric power. As a larger initial input electric power is supplied, a better lumen start-up property is obtained. However, such a larger input electric power may cause damages to the electrodes. Then, an appropriate value of the initial input electric power for superior lumen start-up property without giving excessive damage to electrodes is determined through testing and experiments. In the conventional metal halide discharge lamp comprising mercury, the input electric power of the light emitting tube at cold start is increased to be nearly 200% of the rated electric power. In the conventional mercury-free metal halide discharge lamp, since mercury which greatly contributes to lumen start-up is not included, it takes approximately 6 seconds to reach 80% of the rated luminous flux using the same start-up conditions as for a mercury-containing metal halide discharge lamp described above. This problem is solved in the light emitting tube 1 of the present invention by increasing the input electric power of the light emitting tube 1 to be 300% of the rated electric power in maximum.

[0053] Fig. 11 shows lumen start-up properties of the light emitting tube 1 of the second preferred embodiment depending on varying initial input electric power. A line comprising circular dots shows the lumen output one-second after start-up of the light emitting tube 1. A line comprising squared dots shows the lumen output four-second after start-up of the light emitting tube 1. When the initial input electric power of the light emitting tube 1 is equal to or larger than 90W, the luminous flux within four seconds sufficiently exceeds 80% of the rated luminous flux. When the initial input electric power of the light emitting tube 1 is approximately or larger than 90W, which is approximately 250% of the rated electric power, the luminous flux within one second sufficiently exceeds 25% of the rated luminous flux. When the initial input electric power exceeds 105W, which is approximately 300% of the rated electric power, the electrodes 3 can be damaged.

[0054] In the mercury-free metal halide discharge lamp with a rated electric power of 35W according to the present invention, the lamp voltage of the light emitting tube 1 is approximately 15-25V just after start-up of the light emitting tube 1. The vapor pressure of metal halides increases as the temperature of the light emitting tube 1 increases. The lamp voltage of the light emitting tube 1 becomes approximately 30-50V in steady lighting. When the lamp voltage of the light emitting tube 1 becomes approximately 30-50V in steady lighting, the discharge is stable even when the amount of input electric power to the light emitting tube 1 is decreased for a dimming operation, thereby superior dimming can be performed. Then, by detecting the voltage of the light emitting tube 1, it is able to reduce the input electric power as the lamp voltage of the light emitting tube 1 increases such that instant start-up of the light emitting tube 1 can be achieved without imposing excessive load to the light emitting tube 1.

[0055] Further, both instant lighting-up and dimming can be realized by adopting an electric power supply capable of varying the electric power in a range of 40-300% relative to the rated electric power of the light emitting tube 1. When the light emitting tube 1 of the second preferred embodiment is used as a light source of an automobile headlight, the electric power supplied to the light emitting tube 1 can preferably vary in a range of approximately 57-300% relative to the rated electric power of the light emitting tube 1 for both instant lighting-up and dimming.

[0056] The light emitting tube 1 according to the present invention is not only used in a metal halide lamp 10 with a rated electric power of 35W, but it is also appropriate for being designed to have relatively small size considering an acceptable pressure limit of the light emitting tube, etc., and it is especially suitable as a lamp

designed to have the structure of Fig. 1 and to be driven by a rated electric power of 10-50W. Generally, in a mercury-free metal halide light emitting tube, if the rated electric power of the light emitting tube increases, the current flowing in the light emitting tube increases while the voltage of the light emitting tube does not change very much. As a result, exhaustion of the electrodes of the light emitting tube is promoted, and the lifetime of the light emitting tube 1 is shortened. If larger electrodes are used as a preventive means against exhaustion of the electrodes, the heat loss by the electrodes is increased, and the efficiency of the light emitting tube is decreased. Further, larger electrodes make the light emitting tube difficult to manufacture. On the other hand, if the rated electric power is smaller than 10W, a heat transfer loss of the light emitting tube becomes relatively large due to a larger heat radiation area relative to a predetermined heat amount, and the lumen output efficiency in the visible light wavelength range of the light emitting tube 1 is decreased. Accordingly, if the light emitting tube 1 according to the present invention is used as a lamp with a rated electric power of 10-50W, the rated current is preferably approximately 0.5-1.5A. Further, with the electrodes each having a relatively small diameter of approximately 0.10-0.60 mm, the light emitting tube has superior lifetime property.

[0057] Fig. 9 illustrates the lumen maintenance property of the light emitting tube 1 with a rated electric power of 35W according to the second preferred embodiment of the present invention. The mercury-free metal halide discharge lamp according to the present invention has a superior lumen maintenance property compared to the conventional metal halide discharge lamp containing mercury. In the conventional metal halide discharge lamp containing mercury, the lumen maintenance property decreases to be 60-70% after 2000 hours of lighting.

[0058] Fig. 10 is a chromaticity diagram showing the change of light color emitted from the mercury-free light emitting tube 1 with a rated electric power of 35W according to the second preferred embodiment as lighting hour passes, in comparison with that of a conventional mercury-containing light emitting tube. An area surrounded by dotted lines is the tolerance area of white color specified in JEL 215 by Nihon Denkyu Kogyo-kai for a high intensity discharge lamp used as a light source of an automobile headlight. Numbers in the diagram show lighting hours.

[0059] In the conventional mercury-containing discharge lamp, the light color shifts to bluish white as lighting hours pass, because the light emission from mercury gradually becomes predominant as the metal halides sealed in the discharge chamber are consumed by chemical reactions as lighting hours pass. On the other hand, in the mercury-free light emitting tube 1 of the present invention, since each metal halide sealed in the discharge chamber 2 is consumed at the same rate as lighting hours pass, the chromaticity does not substantially change. The chromaticity point marked by "+" is an objective or best chromaticity point defined by JEL215. It is clearly shown by Fig. 10 that the light emitting tube 1 according to the present invention has an excellent chromaticity property.

[0060] In the metal halide discharge lamp with a rated electric power of 10-50W according to the present invention, the lamp voltage of the light emitting tube 1 during steady lighting is preferably in a range of 20-65V. The lowest voltage of the light emitting tube 1 is determined depending on a voltage drop at the electrodes, which is approximately 15-20V regardless of size of the light emitting tube 1. Therefore, if the lamp voltage of the light emitting tube 1 is smaller than 20V, it is not able to obtain the voltage corresponding to the vapor pressure of the metal halides such that a sufficient luminous intensity cannot be obtained. If the voltage of the light emitting tube 1 is larger than 65V, the impedance of the light emitting tube 1 becomes larger than 75Ω. If the current of the light emitting tube 1 is controlled to decrease when the impedance is larger than 75Ω, the discharge tends to be unstable to an extent that such a light emitting tube 1 is not appropriate for use as a light source, and it is highly likely to bring about unintentional extinguishing of the light emitting tube 1.

[0061] The metal halide lamp according to the present invention can be driven by not only alternating current but also by direct current. If the metal halide lamp is driven by direct current, it is preferable to separately design the electrodes such that they can optimally perform functions of an anode and a cathode. For example, the cathode can be made of a tungsten (W) compound including for example thorium oxide (ThO_2) in order to facilitate the emission of electrons. It is preferable to design the cathode to have a small size for an appropriate temperature rise. The anode can be formed to have a diameter which is 2-4 times larger than the one of the cathode, because the temperature of the anode tends to increase due to the incidence of the electron beam. The material of the anode is preferably pure tungsten.

[0062] Driving the conventional metal halide lamp comprising mercury by direct current results in a color separation of the light emitted from the metal halide lamp, because the metal sealed in the form of metal halide tends to emit light at the side of the cathode rather than the anode, and at the anode side, mercury emits white light which is close to blue. In the metal halide lamp according to the present invention, since the light emitting tube 1 does not include mercury, white light is emitted at any part of the discharge arc. This characteristic is advantageous for the incorporation of the light emitting tube 1 in various optical application devices. In addition, although a switching device is required to an output circuit in case the light emitting tube is driven by an electron stabilizer (ballast) using alternating current, the switching device is not required in case the light emitting tube is driven by direct current. Accordingly, the circuit can be simplified, which leads to production cost reduc-

tion.

[0063] The metal halide lamp 10 according to the present invention is applicable for various usage, and it is not limited to the usage as a light source of an automobile headlight. Further, in the above embodiment, the light emitting tube 1 is formed of silica glass. However, the material is not limited to silica glass, and other material such as ceramics can be used.

[0064] The operational advantages of the present invention will now be described. The metal halide lamp according to the present invention contains no mercury which is a toxic substance giving harmful effect to the environment. Although no mercury is contained, the metal halide lamp of the present invention has a lumen output efficiency in the visible light wavelength range and a lumen maintenance property at the same or higher level of the conventional metal halide lamps. Especially, the metal halide lamp of the present invention has an excellent chromaticity maintenance property both when dimming operation is performed and lighting hours have passed. Furthermore, the metal halide lamp of the present invention has a superior discharge stability such that illumination devices incorporating the metal halide lamp of the present invention can perform a practical dimming function. In addition, the metal halide lamp of the present invention can be used as a light source of an automobile headlight which is also used as a DRL because of its instant start-up property and the practical dimming function. Of course, the metal halide lamp of the present invention can be used without dimming.

[0065] It will be apparent to those skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the invention. Thus, it is intended that the present invention covers the modifications and variations of the invention provided they come within the scope of the appended claims and their equivalents.

Claims

1. A metal halide discharge lamp (10) comprising a light emitting tube (1), the light emitting tube (1) comprising a discharge chamber (2) formed in the light emitting tube and containing no mercury, a pair of electrodes (3) each having a portion which projects into the discharge chamber (2):

    wherein the discharge chamber (2) comprises a buffer gas of xenon (Xe) in an amount of 7-20 atmospheres at room temperature which also acts as a starter gas, and at least one metal halide; and
    wherein the light emitting tube (1) has a range of positive resistance property in current-voltage characteristics relative to a varying input electric power; and
    wherein in the range of positive resistance property, the light emitting tube (1) is driven during steady lighting by an electric power which is equal to or smaller than a rated power.

2. The metal halide lamp (10) according to claim 1, wherein in the range of positive resistance property, electric power supplied to the light emitting tube during steady lighting varies in the range of 57-100 % of the rated electric power during steady lighting.

3. The metal halide lamp (10) according to claim 1 or 2, wherein the metal halide comprises at least sodium iodide and scandium iodide, and a mol fraction of ScI_3 relative to NaI is in a range of 0.05-0.43.

4. The metal halide lamp (10) according to claim 1 or 2, wherein the metal halide comprises at least sodium iodide, scandium iodide and another metal halide, and a mol fraction of ScI_3 relative to NaI is in a range of 0.10-0.43, and a mol percent of the other metal halide relative to all metal halides is in a range of 3-12 mol%.

5. The metal halide lamp (10) according to claim 4, wherein the other metal halide is indium iodide.

6. The metal halide lamp (10) according to any of the preceding claims, wherein a sum of molarities of all metal halides relative to an inner volume per unit of the light emitting tube (1) is in a range of 30-100 $\mu mol/cm^3$.

7. The metal halide lamp (10) according to any of the preceding claims, wherein in a period from start-up of the light emitting tube (1) until it reaches steady lighting, electric power equal to or smaller than 300 % of the rated power is supplied to the light emitting tube (1).

8. The metal halide lamp (10) according to any of the preceding claims, wherein the light emitting tube (1) has a rated electric power of 35W, and a lamp voltage of the light emitting tube (1) just after start-up is in the range of 15-25V, and a lamp voltage of the light emitting tube (1) during steady lighting is in a range of 30-50V.

9. The metal halide lamp according to claim 8, wherein in the range of positive resistance property, a total luminous flux varies in a range of 19-100 % relative to a rated luminous flux.

10. The metal halide lamp according to claim 1, 4 or 8, wherein in the range of positive resistance property, the input electric power varies in a range such that a color of light emitted from the light emitting tube (1) maintains substantial white in the following range in CIE 1931 xy chromaticity diagram.

$x \geq 0.345$ $y \leq 0.150 + 0.640x$

$x \leq 0.405$ $y \geq 0.050 + 0.750x$

11. The metal halide lamp according to any of the preceding claims, wherein the lamp is driven by direct current.

12. A metal halide discharge lamp (10) comprising a light emitting tube (1), the light emitting tube (1) comprising a discharge chamber (2) formed in the light emitting tube (1) and containing no mercury, a pair of electrodes (3) each having a portion which projects into the discharge chamber (2):

wherein the discharge chamber (2) comprising a buffer gas of xenon (Xe) in an amount of 7-20 atmospheres at room temperature which also acts as a starter gas, and at least one kind of a metal halide; and
wherein the light emitting tube (1) has a range where an impedance of the light emitting tube (1) is equal to or smaller than 75Ω in current-voltage characteristics relative to a varying input electric power, and wherein in the range where the impedance of the light emitting tube (1) is equal to or smaller than 75Ω, the light emitting tube is driven during steady lighting by an electric power which is equal to or smaller than a rated power.

13. The metal halide lamp (10) according to claim 12, wherein in the range where impedance of the light emitting tube is equal to or smaller than 75Ω, the electric power supplied to the light emitting tube (1) during steady lighting varies in a range of approximately 40-100 % of the rated electric power during steady lighting.

14. The metal halide lamp (10) according to claim 12, wherein in the range where the impedance of the light emitting tube is equal to or smaller than 75Ω in current-voltage characteristics relative to a varying input electric power, a total luminous flux varies in a range of 15-100 % relative to a rated luminous flux.

15. The metal halide lamp (10) according to any of claims 12 to 14, wherein the at least one kind of a metal halide sealed in the discharge chamber (2) comprises at least sodium iodide (NaI) and scandium iodide (ScI_3).

16. The metal halide lamp (10) according to claim 15, wherein a mol fraction of ScI_3 relative to NaI is in a range of 0.05-0.43.

17. The metal halide lamp (10) according to claim 15, wherein the metal halides further comprise another metal halide, wherein a mol fraction of ScI_3 relative to NaI is in a range of 0.10-0.43, and a mol percent of the other metal halide relative to all metal halides is in a range of 3-12 mol%.

18. The metal halide lamp according to claim 17, wherein the other metal halide is indium iodide (InI).

19. The metal halide lamp (10) according to any of the claims 12 to 18, wherein a sum of molarities of all metal halides relative to an inner volume per unit of the light emitting tube is in a range of 30-100 μmol/cm^3.

20. The metal halide lamp (10) according to any of the claims 12 to 19, wherein in a period from start-up of the light emitting tube (1) until it reaches steady lighting, electric power equal to or smaller than 300 % of the rated power is supplied to the light emitting tube (1).

21. The metal halide lamp (10) according to any of the claims 12 to 20, wherein the rated electric power of the light emitting tube (1) is in a range of 10-50W, and a voltage of the light emitting tube in steady lighting is in a range of 20-65V.

22. The metal halide lamp (10) according to any of the claims 12 to 21, wherein the lamp is driven by direct current.

Fig.1

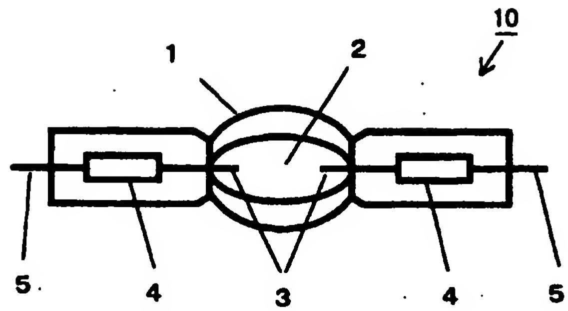

10
1
2
5
4
3
4
5

Fig.2

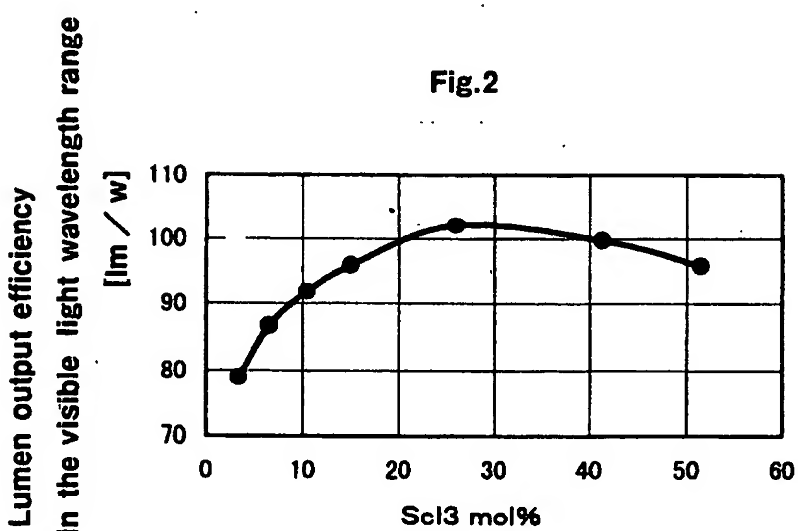

Lumen output efficiency in the visible light wavelength range [lm / w]
110
100
90
80
70
0
10
20
30
40
50
60
ScI3 mol%

Fig.3

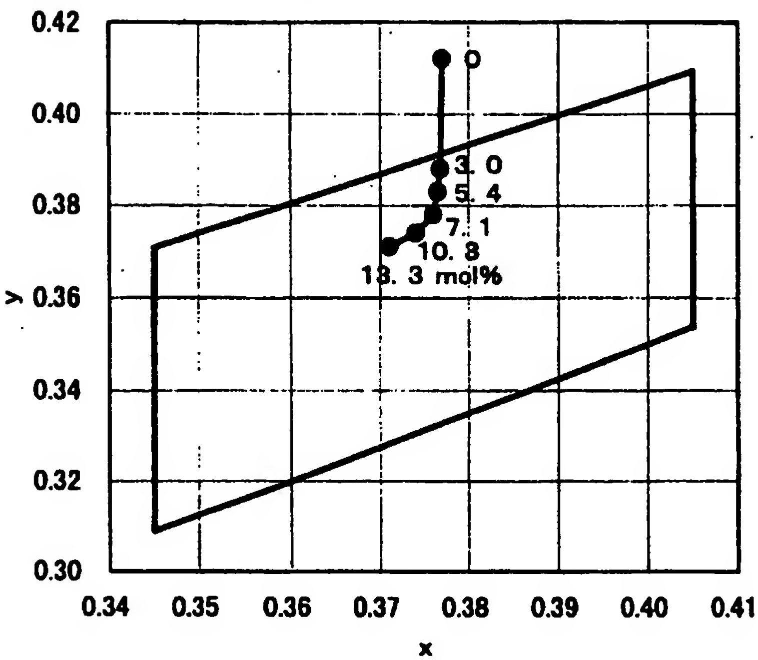

0.42
0.40
0.38
y 0.36
0.34
0.32
0.30
0.34
0.35
0.36
0.37
0.38
0.39
0.40
0.41
x
0
3. 0
5. 4
7. 1
10. 8
18. 3 mol%

Fig.4

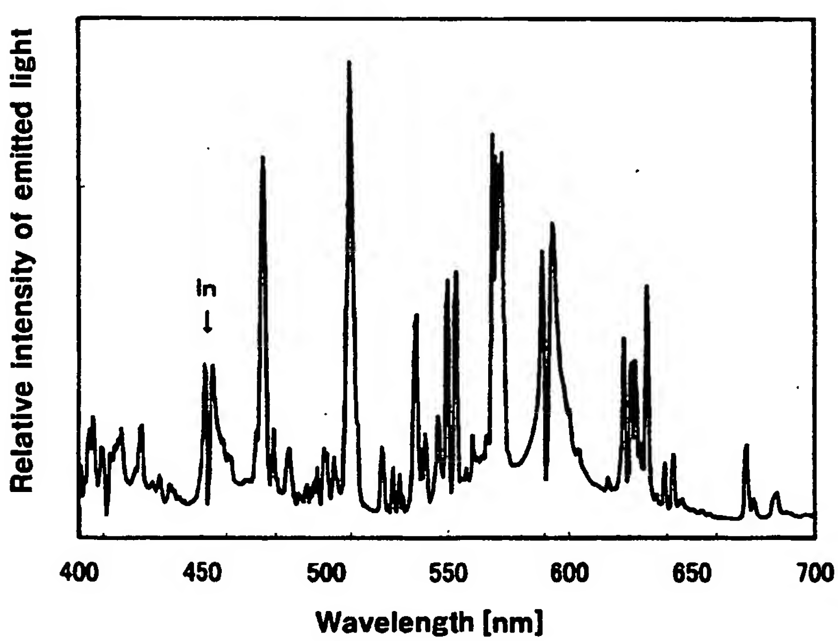

Relative Intensity of emitted light
In
400
450
500
550
600
650
700
Wavelength [nm]

Fig.5

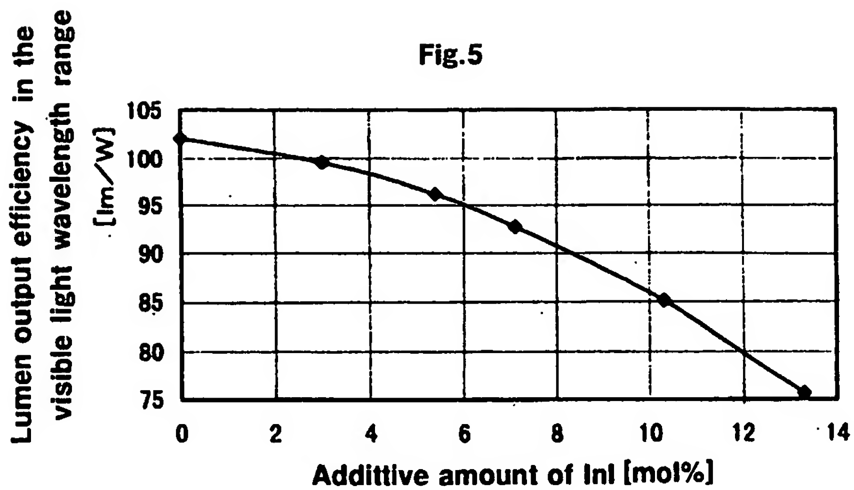

Lumen output efficiency in the visible light wavelength range [lm/W]
105
100
95
90
85
80
75
0
2
4
6
8
10
12
14
Additive amount of InI [mol%]

Fig.6

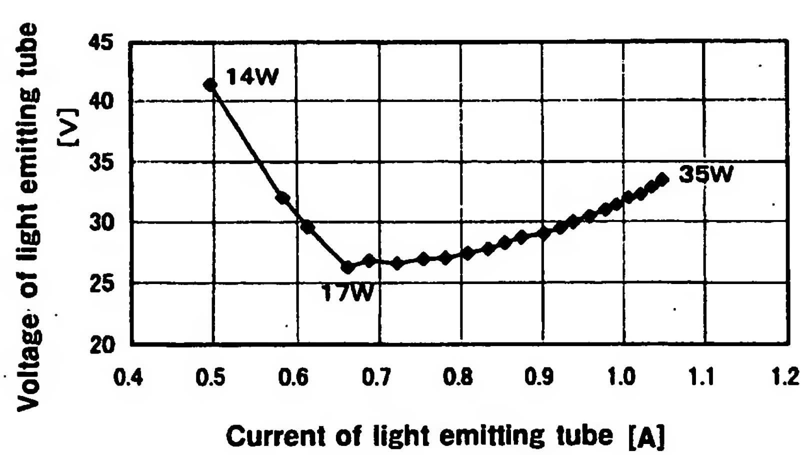

Voltage of light emitting tube [V]
45
40
35
30
25
20
14W
17W
35W
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Current of light emitting tube [A]

Fig.7

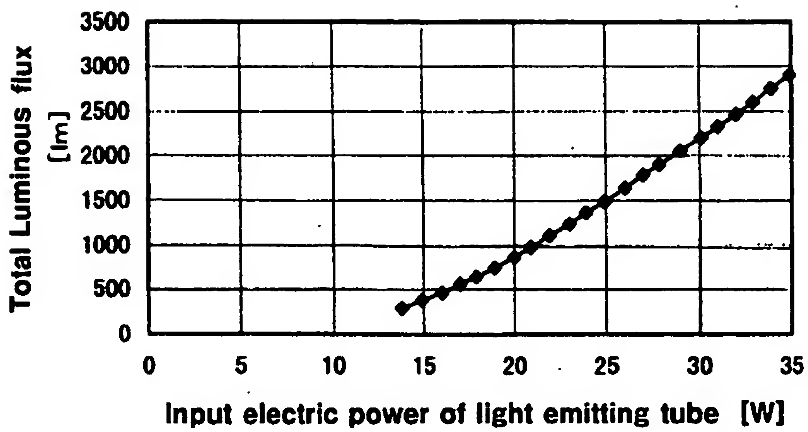

Total Luminous flux [lm]
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
30
35
Input electric power of light emitting tube [W]

Fig.8

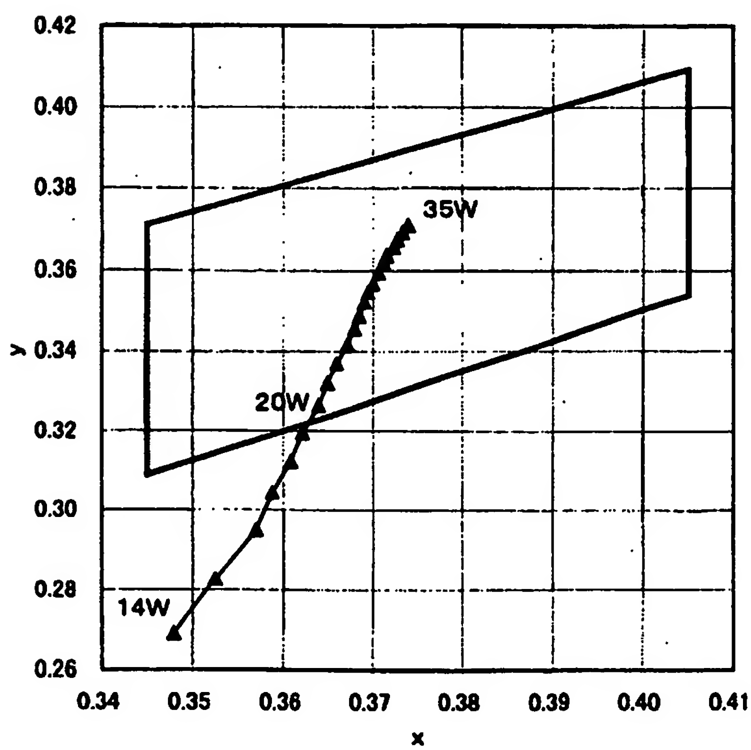

0.42
0.40
0.38
0.36
0.34
0.32
0.30
0.28
0.26
y
35W
20W
14W
0.34
0.35
0.36
0.37
0.38
0.39
0.40
0.41
x

Fig.9

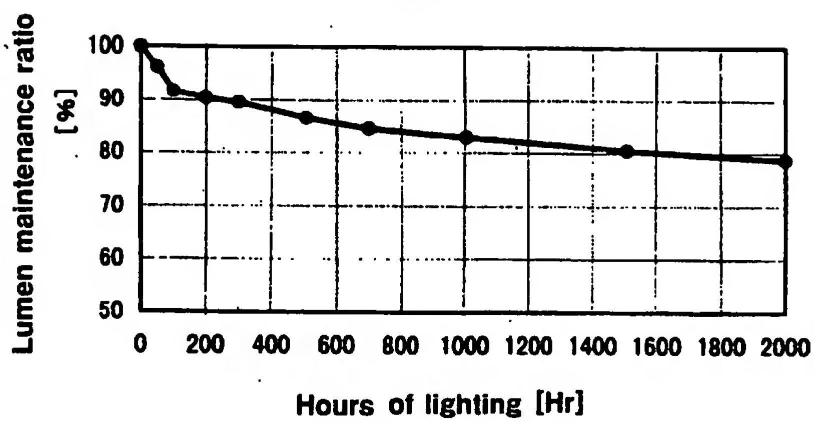

Lumen maintenance ratio [%]
100
90
80
70
60
50
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Hours of lighting [Hr]

Fig.10

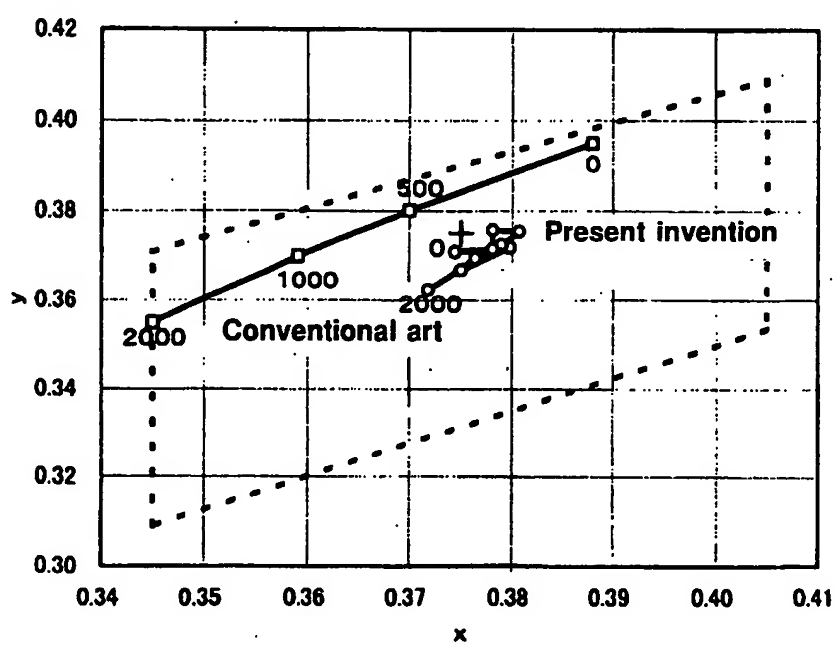
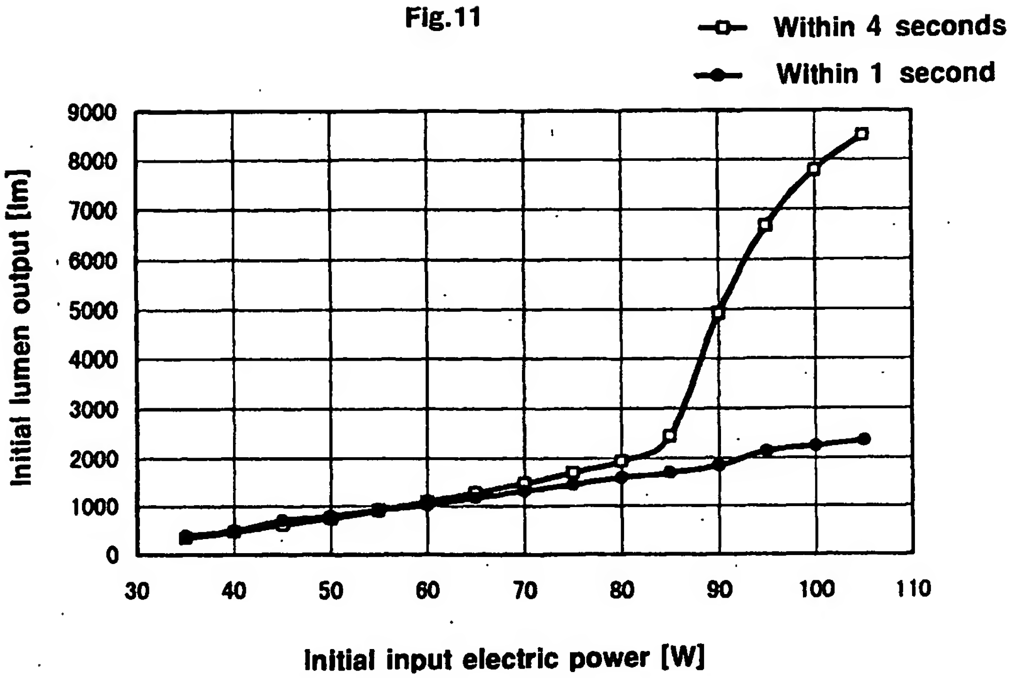

0.42
0.40
0.38
0.36
0.34
0.32
0.30
y
0.34
0.35
0.36
0.37
0.38
0.39
0.40
0.41
x
0
500
1000
2000
Conventional art
0
2000
Present invention

Fig.11


Within 4 seconds
Within 1 second
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Initial lumen output [lm]
30
40
50
60
70
80
90
100
110
Initial input electric power [W]

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 12 0323

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	EP 1 037 258 A (MATSUSHITA ELECTRIC IND CO LTD) 20 September 2000 (2000-09-20) * claims 1,3-22; figures 1-13 *	1-22	H01J61/12 H01J61/82
A	EP 1 037 257 A (MATSUSHITA ELECTRIC IND CO LTD) 20 September 2000 (2000-09-20) * the whole document *	1-22	
A	EP 1 102 307 A (GEN ELECTRIC) 23 May 2001 (2001-05-23) * claims 1-4 *	1-22	
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 12, 3 January 2001 (2001-01-03) & JP 2000 243348 A (MATSUSHITA ELECTRIC IND CO LTD), 8 September 2000 (2000-09-08) * abstract *	1,3,12, 15-17	
D,A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 332 (E-1567), 23 June 1994 (1994-06-23) & JP 06 084496 A (TOSHIBA LIGHTING & TECHNOL CORP), 25 March 1994 (1994-03-25) * abstract *	1,3,12, 15-17	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H01J
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 February 2002	Deroubaix, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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05-02-2002

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